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Steelhead Use of Icicle Creek: A Review

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On the cover*: Oncorhynchus mykiss* caught in a screw trap in the Entiat River. USFWS

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Introduction

This report summarizes the available information regarding anadromous steelhead (*Oncorhynchus mykiss*) use of Icicle Creek, a tributary to the Wenatchee River. With the exception of some historical stocking data, this report is limited to the "recent era" of management and monitoring in Icicle Creek, defined as from approximately the year 2000 up to the present day. This definition is based on the evolution in management practices of the Leavenworth National Fish Hatcheries' (LNFH) in-stream weirs and diversion structures that occurred in response to the listing of spring Chinook salmon (*O. tshawytscha*), steelhead, and bull trout (*Salvelinus confluentus*) under the Endangered Species Act (ESA) in the 1990's. For brevity, only limited descriptions of the physical geography and condition of Icicle Creek are provided, and only the recent history of in-stream weir and diversion structure management is discussed. For more geophysical information about the watershed, see *Summary of Icicle Creek Temperature Monitoring, 2013* (Hall 2013).

History of Hatchery Steelhead Production and Rainbow Trout Stocking

Hatchery Steelhead Production

Throughout the history of anadromous hatchery steelhead production in Icicle Creek, all smolt releases and adult returns occurred below river kilometer (rkm) 4.5 (see Habitat Availability in Icicle Creek, below). Beginning in 1939, steelhead of unknown origin were trapped at Rock Island Dam and transferred to the LNFH for spawning, rearing, and release into Icicle Creek (first release in 1941). Due to poor adult returns and inadequate water supply, this program was terminated after the 1951 smolt release (USFWS 1995).

In 1977, improved water sources allowed the LNFH to resume a steelhead program, with a goal of releasing 100,000 smolts per year. This program continued to have poor adult returns, and in several years, eggs or broodstock of unknown origin from the Wells Fish Hatchery were transferred to the LNFH to meet production goals (USFWS 1995). The LNFH's steelhead program was terminated with the final smolt release in 1997.

From the 1960's through the early 1990's, the Washington Department of Fish and Wildlife (WDFW) and the Chelan County Public Utility District (CCPUD) released hundreds of thousands of hatchery steelhead into Icicle Creek, and several million into the Wenatchee River. Currently, the WDFW has an annual goal of releasing 200,000 steelhead smolts into the Wenatchee River. These fish are acclimated and released into several reaches and tributaries of the Wenatchee River, but not directly in Icicle Creek.

Rainbow Trout Stocking

Icicle Creek, and its surrounding lakes, have been stocked with rainbow trout since at least 1933. Thousands to tens-of-thousands of rainbow trout of various life stages were planted annually until the mid-1990's, when stocking of most Washington streams ceased (WDFW pers. com.). Mountain lakes in the basin are still occasionally stocked with rainbow trout fry. The rainbow trout planted directly into Icicle Creek were reared at several mid-Columbia river hatcheries,

including the LNFH, Chiwaukum State Fish Hatchery, Methow State Fish Hatchery, and others (WDFW pers. com.). The genetic lineage of the broodstock used at these facilities is complex, with at least 15 different rainbow trout broodstock sources from public and private hatcheries in California, Nevada, Utah, Massachusetts, Missouri, Idaho, Montana, and Washington state (Chapman et al. 1994, Crawford 1979). Many of the distant broodstock sources were used in the early decades of Washington state hatchery development, when selection for early maturation, high growth rates, and appearance were the concerns of hatchery managers. In recent decades, efforts were made to develop "local" broodstocks, though stocking had become so ubiquitous that finding completely "pure" interior redband rainbow trout broodstock was unlikely, and not necessarily the goal ("local" broodstock was not interpreted as meaning "pure" in the genetic sense). Much of this work pre-dated modern genetic analysis, and relied on taxonomic characteristics to assign lineages. A few years after the cessation of trout stocking directly into Icicle Creek, Proebstel (1998) found that 12 salmonids captured at one location in upper Icicle Creek were "essentially pure" interior redband rainbow trout, based on taxonomic analysis. The only modern genetic analysis of rainbow trout in Icicle Creek is being conducted by the Wild Fish Conservancy. Their work is currently under review for publication.

Habitat Availability in Icicle Creek

Icicle Creek has a long history of manipulation, including channelization, diversion, and discharge regulation. Most of these alterations have occurred in the lower 9.0 rkms, where nearly all of the residential and agricultural development has occurred. Upstream of rkm 9.0, Icicle Creek is bounded by National Forest and designated Wilderness, limiting development to undeveloped roads and campgrounds (Figure 1).

For this report, only the lowest 9.0 rkm will be considered *naturally* available to anadromous steelhead. The ability of fish to pass upstream of the Boulder Falls at rkm 9.0 has been in question for many years. Cappellini (2001) and Nelson et al (2012) radio-tagged steehead, spring Chinook salmon, and adult (migratory sized) bull trout in Icicle Creek for movement studies, and reported that none of the fish tagged moved above the Boulder Falls, though some did move from lower in the basin up to the lower extent of the Falls. To date, no conclusive reports of successful upstream passage have been published. Some of the debate over the "passability" of the Boulder Falls has revolved around the time-frame of the Boulder Falls formation (recent or geologic?). A recent geomorphological study concluded that most of the constituent elements of the Boulder Falls have been in place since glaciation (Dominguez et al 2013).

The occurrence and/or frequency of downstream fish passage of the Boulder Falls is unstudied. Nelson (pers. com.) has obtained recent genetic data conforming that a migratory-sized bull trout found below the Boulder Falls originated from resident populations above, demonstrating that downstream movement does occur. Courter et al (2013) found that in the Yakama basin, up to 20% of the anadromous steelhead had resident maternal life histories. Because rainbow trout have the ability to produce anadromous steelhead, the habitat above the Boulder Falls may be producing out-migrating steehead smolts. To compound the issue, rainbow trout of resident size also occur below the Boulder Falls, suggesting that either resident spawning is occurring below

the Boulder Falls or resident rainbow trout are migrating downstream through the Boulder Falls and continuing the resident life history.

This report divides the lowest 9 rkms of Icicle Creek into 3 reaches (Figure 1). The lowest reach begins at the confluence of Icicle Creek and the Wenatchee River, and concludes at the Structure 5 bridge and picket weir (S5) at rkm 4.5. This section is referred to as the "Lower Icicle" reach. The middle reach of Icicle Creek begins at S5 and concludes at the Structure 2 headgate (S2) at rkm 6.1. This reach is commonly referred to as the "Historical Channel". The uppermost reach discussed in this report begins at S2 and ends at the Boulder Falls at rkm 9.0. This reach is referred to as "Above the LNFH".

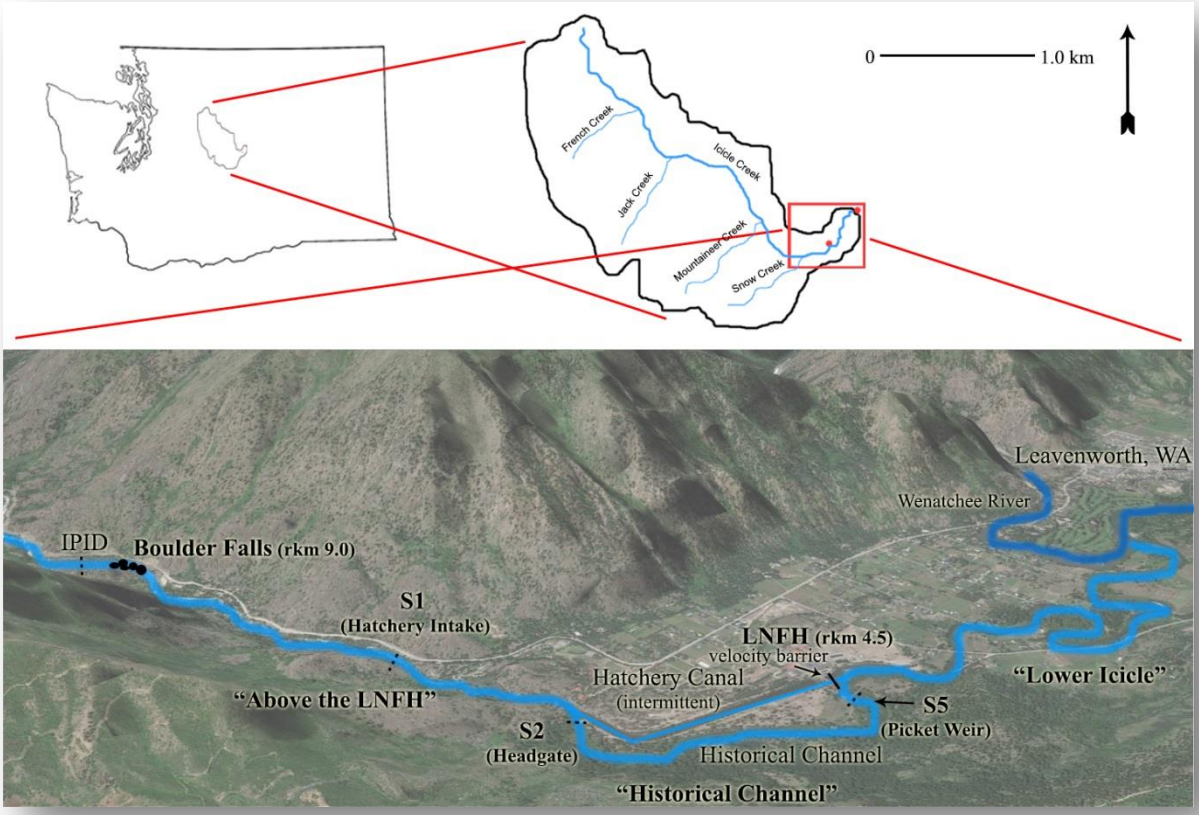

Figure 1. The lower 9.0 rkm of Icicle Creek with selected structures and landmarks.

Lower Icicle Creek

The Lower Icicle reach has been completely available to adult and juvenile steelhead in the recent era, though the habitat is degraded due to residential and agricultural development (Andonaegui 2001).

Historical Channel

In the Historical Channel, the history of structure operations, and the trapping and passing of adult fish is very complicated, with sporadic documentation and anecdotal accounts. A general statement can be made that the Historical Channel was mostly unavailable to adult steelhead until 2006. Until this time, the S5 picket weir was used, in conjunction with the S2 radial gates, to manage discharge and prevent adult spring Chinook salmon from migrating upstream of S5. Most of the evolution of Historical Channel management was focused on spring Chinook salmon management, and later bull trout passage. From 2000 until 2011, there was a general increase in the amount of time the Historical Channel was available to adult fish, however steelhead passage was not the focus of these changes. And while passage options were increased at the S5 picket weir (and into the Historical Channel), the S2 radial gates were still in use, limiting further upstream movement.

Until 2003, the Historical Channel contained 2 additional channel-spanning structures (S3 and S4) between S2 and S5. These structures were part of the original LNFH design, and were utilized for in stream holding of adult fish. Use of these structures resulted in converting the Historical Channel "from riverine to wetland habitat" (USFWS 2002). These structures slowed water velocities and trapped sediment, rendering the Historical Channel poor habitat for adult spawning. However, there are anecdotal accounts of use of the Historical Channel by juvenile fish, including *O. mykiss*. The picket weirs at S5 were not designed to exclude juvenile fish, so upstream movement of juvenile fish is possible, as well as downstream movement through S2.

In 2003, S3 and S4 were completely removed. Since then, with increasing amounts of Icicle Creeks' discharge being allowed to run through S2 and the Historical Channel, the former "wetland habitat" has begun to revert to riverine habitat. Much of the sediment has been transported downstream, as well as deposition of new sediment from upstream sources. The dense vegetation that took root during the "wetland" years has anchored islands and created braided channels and diverse habitats. Cobble substrates have been re-exposed. It appears that the development of the higher-functioning riverine habitat constitutes some of the best juvenile rearing habitat in lower Icicle Creek (below the Boulder Falls), though no specific research has been conducted to validate this claim.

In 2005, a group of regional experts was convened to assess the potential salmon and steelhead spawning habitat in the Historical Channel and Above the LNFH reaches (up to rkm 8.8) (Thomas 2005). This group consisted of biologists from NOAA, USFWS, WDFW, USFS, and the Yakama Nation, and was tasked with estimating the amount of suitable spawning habitat, using their professional judgment as to the appropriate substrate size and hydraulic conditions. The group estimated that there was 1,822m^2 of spawning habitat suitable for steelhead in the Historical Channel, and 26m^2 in the Above the LNFH reach (up to rkm 8.8). This study was conducted 2 years after the removal of S3 and S4, and presumably, the Historical Channel was in the process of transitioning from wetland to riverine habitat. The study notes that (at that time) substrate embeddedness remained high in some parts of the Historical Channel, and that spawning habitat may improve with increased sediment-flushing discharge.

In 2011, the Biological Opinion for the Operations and Maintenance of the LNFH (USFWS 2011) included a proposed action (within the Biological Assessment) that S2 is to remain in the

fully open position year-round, with 5 conditions that allow for closure under specific, short-term circumstances. Since 2011, S2 has only been closed for a few weeks each year, and the Historical Channel has experienced increased discharges and a hydrograph that approaches pre-hatchery development conditions. With S2 fully open, the Historical Channel can now receive a maximum of about 2000 cfs, with the remaining discharge being diverted into the Hatchery Canal (Figure 2). Under these higher discharge regimes, deposition, scour, and channel alteration have been noticed, though no research or monitoring is being conducted to track the effects of this increase in discharge on the habitats of the Historical Channel.

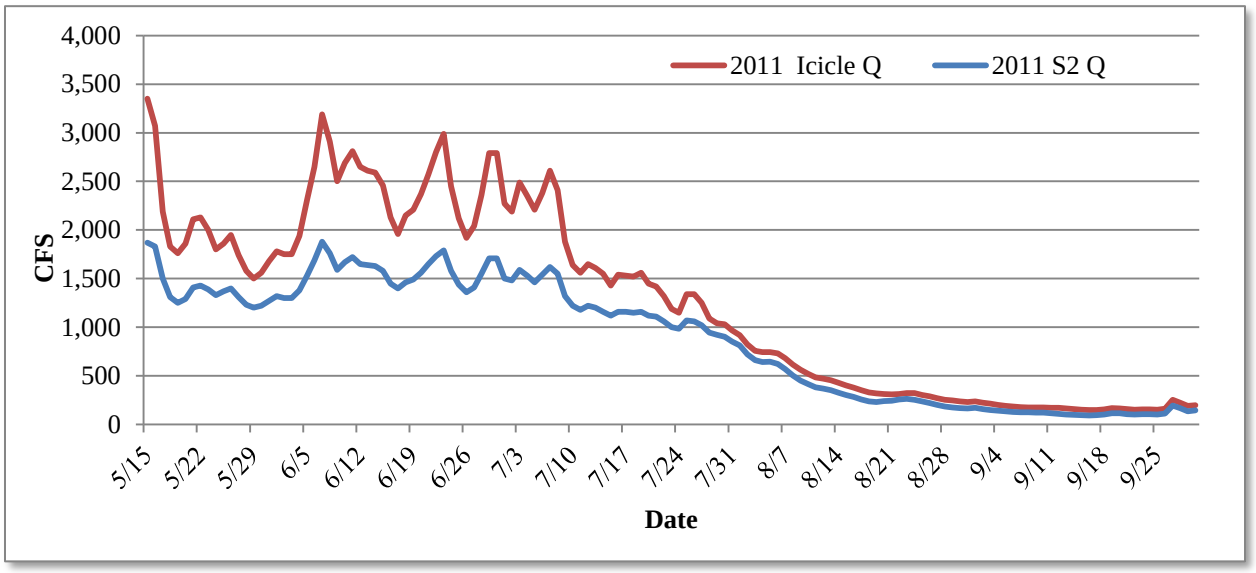

Figure 2. Icicle Creek discharge (Q) measured at the Washington Department of Ecology station gauge (ID# 45B070) and calculated discharge through S2 during the spring and summer of 2011. S2 discharge was calculated using methods in Hall (2014).

Above the LNFH

The Above the LNFH reach was only periodically available to adult steelhead before 2011. The Above the LNFH reach is generally considered poor spawning habitat, as it is a geologically defined canyon of high gradient, containing large boulders and cascades. As mentioned earlier, the 2005 spawning habitat study concluded that this reach had relatively little steelhead spawning habitat. This reach has been mostly unchanged in the modern era, with some residential development occurring, and some large fire and flood events. Since 2011, the Above the LNFH reach has been available to adults nearly year-round.

The ability of juvenile fish to pass S2, separating the Historical Channel from the Above the LNFH reach, is an important consideration with regard to juvenile use of Icicle Creek, and this the subject of recent research. Using hydraulic modeling, Anglin et al (2013) suggest that there is no flow regime through S2 at which small fish can pass upstream. Under all discharges, either the depth of water through S2 is too shallow, or the velocity is too high (usually the later). Using direct monitoring of fish passing S2, Hall (2014) found very few small fish (<40cm) passed

upstream through S2, however his research was limited to higher discharges and the spring season. Nelson (pers. com.) has received genetic confirmation that sub-adult (<450mm) bull trout captured upstream of all of the LNFHs' diversion structures are from populations of bull trout outside of Icicle Creek. These fish must have passed upstream through S2 at some point. Located at rkm 7.1 in the Above the LNFH reach, Structure 1 (S1) is used by the LNFH and the Cascade Orchards Irrigation Company to withdraw water from Icicle Creek. Structure 1 consists of a low-head dam that diverts water into an intake pipe. This structure is approximately 2 meters high, and spans Icicle Creek. It has a debris flume at one end that was designed to allow river debris to be funneled away from the intake pipe. It is generally considered a fish passage obstacle, though it is known that fish are able to pass it. It is believed that large fish can jump S1, and the debris flume has been modified to act as a ladder. Anglin et al (2013) found that the debris flume (with all of its boards in place) could function as a fish ladder under low discharge conditions. Under high discharge, the debris flume is completely inundated (and, by necessity, the boards are removed), rendering the flume unusable as a fish ladder. However, Anglin et al (2013) concluded that under high discharges, the low-head component of Sl became more conducive to direct passage (i.e. jumping).

Adult Steelhead Use of Icicle Creek

Spawning Ground Surveys

Steelhead spawning ground surveys are notoriously difficult. Spawning occurs in the spring, often under high river discharge. Surveys are often suspended near the peak of the spawning run due to safety concerns and poor visibility.

In Icicle Creek, steelhead spawning ground surveys are conducted by the WDFW, and the results (along with two other species) are given in Table 1. According to their report, surveys conducted since 2004 have used the same methods and reach delineations (Hillman et al 2013). In Icicle Creek, only the Lower Icicle and Historical Channel reaches are surveyed, leaving the spawning use of the Above the LNFH reach unknown. The unavailability of the Historical Channel to adult steelhead before about 2006 is evident in the data, with almost no redds found prior to 2010. A pattern has developed since the opening of the Historical Channel, with only a few steelhead redds (2.8% [SD=3.2] of Icicle Creek total, 2006-2012) being found in this reach each year (that is generally considered to have good habitat). These redds may be "founders" of this (relatively) new habitat, and use of the Historical Channel may increase with time. Or there may be other factors to consider. Coho salmon also seem to use the Lower Icicle reach more than the Historical Channel (31% [SD=11] of Icicle Creek total, 2004-2013). However, spring Chinook salmon use the Historical Channel much more than the Lower Icicle reach. Note that spring Chinook salmon and coho salmon are produced at the LNFH, and this may influence their use of Icicle Creek. Gravel size (chosen for redds) in the Historical Channel may favor the larger Chinook over the smaller steelhead and coho. Much remains unknown about the use of Icicle Creek by adult steelhead.

Table 1. Icicle Creek redd counts for selected species from 2004 to 2013. Blank cells were not surveyed.

Steelhead										
Reach	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Lower Icicle	23	8	39	6	37	102	116	175	43	46
Historic Channel			2	0	0	0	4	5	4	2
Above the LNFH										
Spring Chinook										
Reach	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Lower Icicle	30	8	1	4	23	2	15	17	22	2
Historic Channel			49	11	59	21	113	86	143	84
Above the LNFH			0	2	34	9	27	19	34	21
Coho										
Reach	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Lower Icicle	301	452	42	888	173	637	63	1131	155	48
Historic Channel	203	177	46	360	24	128	35	532	69	25
Above the LNFH				19		0	0	1		0

From 2004-2012, the steelhead redds in Icicle Creek constituted 10.2% (SD=5.8) of all the steelhead redds found in the Wenatchee basin (Hillman et al 2013, Table 2). This is comparable to the proportion of steelhead redds found in Chiwawa River (8.3%) and Peshastin Creek (11.9%).

Table 2. Redd counts for the Wenatchee basin and tributaries from 2004-2012 (WDFW data).

	Wenatchee River	**Icicle Creek**				**Wenatchee Main (includes Chiwakum)**		**Chiwawa River**		**Nason Creek**		**Peshastin Creek**	
Return Year	**Total**	**Redds**	**Lower**	**H.C.**	**% of Total**	**Redds**	**% of Total**	**Redds**	**% of Total**	**Redds**	**% of Total**	**Redds**	**% of Total**
2012	415	47	43	4	0.113	137	0.330	8	0.019	158	0.381	65	0.157
2011	932	179	174	5	0.192	323	0.347	77	0.083	235	0.252	115	0.123
2010	969	118	114	4	0.122	380	0.392	74	0.076	270	0.279	118	0.122
2009	662	102	102	0	0.154	327	0.494	75	0.113	126	0.190	32	0.048
2008	286	37	37	0	0.129	100	0.350	11	0.038	88	0.308	49	0.171
2007	159	6	6	0	0.038	46	0.289	11	0.069	78	0.491	17	0.107
2006	395	41	39	2	0.104	191	0.484	19	0.048	77	0.195	67	0.170
2005	1140	8	8	NA	0.007	459	0.403	162	0.142	412	0.361	97	0.085
2004	397	23	23	NA	0.058	151	0.380	62	0.156	127	0.320	34	0.086
Mean	**595**				**0.102**		**0.385**		**0.083**		**0.308**		**0.119**
SD	**345**				**0.058**		**0.068**		**0.046**		**0.095**		**0.042**

Composition of Adults

Hatchery steelhead originating from the LNFH have not been present in Icicle Creek since about 2000. As such, all steelhead found in Icicle Creek in the recent era are either from natural production or from other hatchery programs. Historically, hatchery-origin steelhead have been planted throughout the Wenatchee basin, including into Icicle Creek. Recently, steelhead have not been planted directly into Icicle Creek, but plantings have occurred in the Wenatchee River very near the mouth of Icicle Creek.

Steelhead spawning ground surveys rarely recover carcasses due to both life history characteristics and environmental conditions. As a result, we know very little about the composition of the spawners in Icicle Creek. In the fall of 2011, a Passive Integrated Transponder (PIT) tag array was installed in Icicle Creek very near the mouth (PTAGIS ID = "ICL"). From this array, we can ascertain some information from some of the adult steelhead that use Icicle Creek. Both stray hatchery adults from within the basin as well as wild fish appear to be using Icicle Creek for holding and/or spawning. A summary of the late winter and spring detections of adult steelhead detected at the ICL array in 2012 and 2013 is given in Table 3. This data only indicates that a fish with a PIT tag was present. It does not indicate direction of motion (entering or leaving Icicle Creek), tagging rates, detection efficiency, spawning location, or spawning success.

Table 3. A summary of adult steelhead PIT detections at the ICL array after 2/1 in 2012 and 2013.

Year	Unique PIT Tags	Origin	Tagging Stage	Tagging Location
2012	23	W	Adult	Dam
2012	1	W	Smolt	Wentachee River
2012	14	H	Adult	Dam
2012	5	H	Smolt	Wentachee River
2012	4	H	Smolt	Headwaters
2012	1	U	Adult	Dam
2013	20	W	Adult	Dam
2013	7	H	Smolt	Wentachee River
2013	1	H	Smolt	Dam
2013	1	H	Smolt	Headwaters
2013	14	H	Adult	Dam
2013	2	U	Adult	Dam

Juvenile Steelhead Use of Icicle Creek

Icicle Creek is home to both juvenile steelhead and resident rainbow trout, though no studies have been conducted to determine the abundance or distribution of either form below the Boulder Falls. Kelly Ringel (1997) found that in a snorkel survey of Icicle Creek from S1 (below the Boulder Falls) to Trapper Creek (above the Boulder Falls), 99% of the fish observed were *O. mykiss*. Below the Boulder Falls, the presence of the anodromous form of juvenile *O. mykiss* is surmised by the fact the anadromous adults spawn in Icicle Creek. And the presence of the resident form is surmised by the fact that large *O. mykiss* (>200mm) have been found. Mullan et al (1992) suggests that juvenile steelhead in the upper Columbia River may reside in freshwater for up to 7 years before smolting, but that migratory smolts are usually <200mm, regardless of age.

Juvenile Distribution

The Mid-Columbia River Fisheries Resource Office (FRO) has conducted summer snorkel surveys of Icicle Creek from the Boulder Falls to the mouth, using consistent methods, since 2006. These surveys are conducted around the first week in August, and are focused on adult Chinook salmon and bull trout. However, the presence of other species is often noted. Summarizing their results and notes from surveys conducted in the summer from 2006-2013, juvenile and resident-sized *O. mykiss* are always common-to-abundant in the Historical Channel and Above the LNFH reaches, and are only occasionally noted in the Lower Icicle reach. This pattern of distribution is in agreement with the general habitat characteristics of the reaches and the habitat preferences of the species. The Historical Channel and Above the LNFH reaches are widely considered to have better *O. mykiss* habitat than the Lower Icicle reach.

The LNFHs' water intake system is not properly screened to prevent fish from entering the intake pipe at S1. The LNFH is required to periodically inspect and remove fish entrained in its water intake system. These inspections are commonly precluded in the winter and spring due to ice and debris. From 2009-2013, the number of *O. mykiss* removed ranged from 30 (2011) to 63 (2009, 2012, LNFH pers. com.). These fish are usually <200mm, though a few were >400mm. This suggests that *O. mykiss* are reasonably abundant in the Above the LNFH reach, though the origin of these fish remains unknown.

Juvenile Production

The productivity of spawning steelhead in Icicle Creek has not been studied, and the most significant missing component to such investigation is the abundance of juvenile steelhead. The best approximation that can be made involves using survival estimates that are derived from the nearby and much more intensively studied Chiwawa River. Using Chiwawa River data found in Hillman et al (2013), the relationship between redd number and egg-to-age-0 survival is shown in Figure 3. The relationship between redd number and egg-to-age-1 survival is shown in Figure 4. Applying the Chiwawa River steelhead survival regression and fecundity estimates (by year), an estimate of age-0 (<100mm) and age-1 (100-200mm) steelhead production in Icicle Creek can be calculated, and is shown in Table 4.

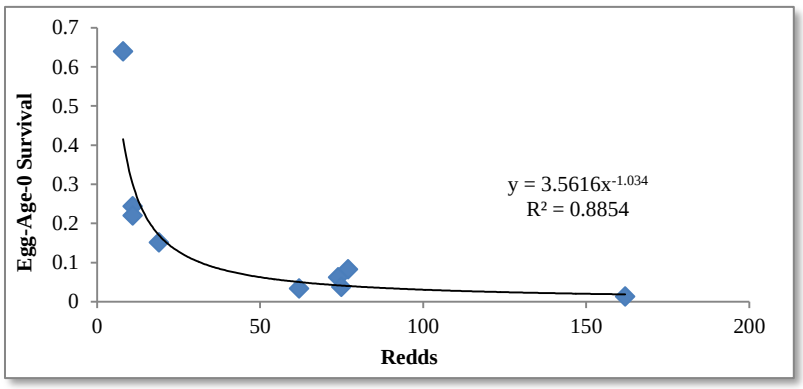

Figure 3. The relationship between steelhead redds and egg-to-age-0 survival in the Chiwawa River (WDFW data).

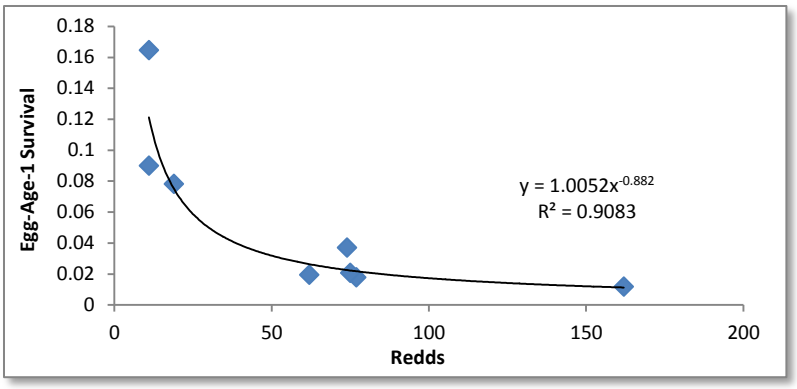

Figure 4. The relationship between steelhead redds and egg-to-age-1 survival in the Chiwawa River (WDFW data).

Table 4. Estimates of productivity of steelhead redds in Icicle Creek from 2004-2013, using relationships from the Chiwawa River.

Brood Year	Redds	Fecundity	Eggs	Egg to Age-0 Survival	Age-0 Recruits	Egg to Age-1 Survival	Age-1 Recruits
						0.033	9,017
2013	48	5,681	272,688	0.065	17,738	0.034	8,406
2012	47	5,309	249,523	0.066	16,588	0.010	11,635
2011	179	6,276	1,123,404	0.017	18,738	0.015	9,633
2010	118	5,458	644,044	0.026	16,529	0.017	10,754
2009	102	6,199	632,298	0.030	18,866	0.042	8,763
2008	37	5,693	210,641	0.085	17,934	0.207	7,252
2007	6	5,840	35,040	0.559	19,570	0.038	8,862
2006	41	5,688	233,208	0.077	17,855	0.161	7,124
2005	8	5,545	44,360	0.415	18,401	0.063	7,448
2004	23	5,118	117,714	0.139	16,385		

*2013 fecundity is the mean of 2004-2012 fecundity.

The Chiwawa River and the lower 9.0 rkm of Icicle Creek are very different, so the validity of using the Chiwawa River as a model is questionable. The redds and juveniles used in the Chiwawa River model are spread over 50 rkms and 7 tributaries. In contrast, though the number of redds are roughly equal, only 9 rkms of Icicle Creek are available, with 1 tributary (Snow Creek) that has a known fish barrier very near its confluence. If this production model were accurate for Icicle Creek, then summing the mean number of age-0 (18,024) and age-1 (8,875) steelhead (2005-2013) would result in an estimate of the yearly mean number of juvenile steelhead in Icicle Creek of 26,859 fish. This equates to 2,989 juvenile steelhead per rkm; an unrealistically high density. As most of the spawning occurs in the Lower Icicle reach, some of the juveniles from Icicle Creek redds may move downstream into the Wenatchee River for rearing, or the productivity of the steelhead redds in Icicle Creek may not be as high as that of the Chiwawa River.

Discussion

Available data indicates that Icicle Creek provides a considerable portion of the spawning habitat for summer steelhead in the Wenatchee basin, constituting approximately 10% of observed redds annually. These redds are almost entirely confined to the Lower Icicle reach, with the spawning habitat above S5 providing less than 3% of all of the redds observed in Icicle Creek since 2004. This suggests that the degree to which the current operation of LNFH in-stream structures and weirs impact steelhead spawning is low, with less than 1% of the redds in the Wenatchee basin potentially impacted by LNFH operations.

The relationship between Icicle Creek spawning and subsequent juvenile steelhead production is unclear. Assuming that the conditions that govern juvenile production in the nearby Chiwawa River basin apply in Icicle Creek, we estimate that annual juvenile production could be as high as 18,024 age-0 fish. This estimate, while likely an overestimate, provides a starting point for estimating the number of juveniles that Icicle Creek may produce. The pattern of distribution of juvenile *O. mykiss* noted in snorkel surveys places most of the juvenile rearing in the Historical Channel and Above the LNFH reaches. This does not directly align with the distribution of adult steelhead redds, with most of the redds occurring in the Lower Icicle reach. Until recently, a "restricted movement paradigm" (Gowan et al 1994), proposed by Gerking (1959), suggested that salmonids in freshwater habitats are largely sedentary, with fish rarely moving more than 20m (not including migration behavior). Many recent studies have demonstrated the contrary. Thomas et al (2001) found that in western Washington streams, the summer movement of juvenile anadromous salmonids was very common, with upstream movement dominating, distances of up to 200m covered, and that the fish that moved had increased growth rates. In Icicle Creek, upstream movement from redds (built in the Lower Icicle reach) to areas of better rearing habitat (the Historical Channel) is a possible explanation for the discrepancy between redd location and juvenile rearing observations. It is also possible that the majority of anadromous juveniles produced in the Lower Icicle reach move downstream into the mainstem Wenatchee River. Unfortunately, a third possibility is that redds built in Icicle Creek are unproductive, and that all of the *O. mykiss* found in Icicle Creek originate from resident trout.

There is a nearly complete lack of information regarding the size and structure of the resident *O. mykiss* population in Icicle Creek. Past stocking information suggests that this population has been influenced by a number of out of basin transfers from other interior redband trout hatchery populations. A key uncertainty confronting fisheries managers in the upper Columbia River is a lack of understanding of the relationship between the anadromous and resident life history forms, and the relative abundance of the two life history forms in areas where their distributions overlap. The section of Icicle Creek below the Boulder Falls is a prime example of this challenge. Fisheries managers are unable to distinguish between the ESA-listed anadromous juveniles and the unlisted resident rainbow trout. This contributes to a considerable amount of uncertainty regarding estimates of juvenile abundance and survival for the ESA-listed population. The extent to which resident rainbow trout contribute to the anadromous population may be largest knowledge deficit facing those managing ESA-listed steelhead in Icicle Creek.

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